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Status Report

SELECTION OF DEPOSYSTEM FOR HETEROGENEITY RESEARCH

(Project BE1, Task 1, Milestone B in FY86 Annual Plan dated April 1986)

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SELECTION OF DEPOSYSTEM FOR HETEROGENEITY RESEARCH

by Susan R. Jackson*

ABSTRACT

Five criteria were established for selecting a depositional environment to analyze to develop a methodology for constructing quantitative models of reservoir heterogeneities. The criteria are (1) the deposystem is an economically important oil reservoir, (2) reservoirs comprised of the deposystem are EOR candidates, (3) the productive formation is exposed near a producing field, (4) subsurface data for the producing field are available to NIPER, and (5) the producing field has an EOR project.

Two depositional environments satisfy these criteria: barrier island/strandplain and shelf sand ridge deposits. Results of a survey of 77 fields producing from barrier island/strandplain deposits and 22 from shelf deposits indicate that six barrier fields and two shelf fields are U.S. giant oilfields (ultimate recovery >100 million barrels). Ultimate recoveries from two fields producing from combined barrier island strandplain deposits have been estimated at >500 million barrels. EOR projects have been conducted in 22 barrier island strandplain reservoirs and 4 shelf reservoirs. Residual oil saturation after primary and secondary recovery in the eight barrier/ strandplain reservoirs sampled, ranges from 31.5 to 55 percent, averaging 38.7

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percent. Insufficient data exist for shelf sand ridge reservoirs to obtain comparative figures.

These depositional environments also satisfy the above-mentioned criteria 3-5. Bell Creek field produces from a barrier island/strandplain deposit which crops out nearby. Subsurface data and data on two micellar-polymer pilot projects implemented in the field are available in Department of Energy reports. Teapot Dome (NPR-3) produces from a shelf sand ridge deposit which is exposed 5 miles from the reservoir. Much subsurface data are on hand at NIPER, and data on the polymer, in situ combustion, and steam pilot projects are available from the NPR office in Casper, WY. The final selection of a reservoir for study will be submitted in a status report due September 30, 1986.

BACKGROUND

One objective of project BE1 is to develop a methodology for constructing quantitative models of reservoir heterogeneities. An underlying assumption of the research plan is that many important heterogeneities such as shale lengths and distribution, stratification, and permeability and porosity spatial distributions are mostly a function of the environment in which the rocks were originally deposited and that understanding depositional patterns will aid in modeling the quantitative effects of these heterogeneities on fluid flow.

The purpose of task 1 is to select a depositional environment to study for development of methods to model reservoir heterogeneities quantitatively. The resulting model is expected to improve predictability of flow patterns, recovery, and spatial distribution of oil after secondary and tertiary recovery operations.

CRITERIA FOR SELECTION OF DEPOSYSTEM

The initial approach as described in the proposed FY 86 Annual Research Plan for selecting a depositional environment for study was to use the psuedo Dykstra Parsons (V_{PDP}) coefficient recorded in the NPC study data base as a method to assess the aggregate heterogeneities of various deposystems. However, results of a study reported in DOE Report No. NIPER-145 indicate that due to large variations in values, no correlation could be made between V_{PDP} and depositional environment. Therefore, the aggregate heterogeneities of depositional environments could not be classified according to the V_{PDP} coefficient values listed in the data base.

The alternative procedure outlined in the FY86 Annual Plan was based on the selection of a depositional environment that has high original oil in place (OOIP) and high residual oil saturation (ROS) after waterflooding. Because poor recovery performance during primary and secondary recovery operations is largely due to geological heterogeneities, it is in reservoirs such as these that heterogeneity research has the potential for significant contributions. This criterion is therefore the primary criterion on which selection of the deposystem should be based.

Three other criteria not specifically associated with the depositional environment but essential for the execution of the project are as follows:

1. The productive formation is exposed near a producing field. This is important because the research strategy involves using outcrop data to supplement subsurface data.

2. That subsurface data from the producing field are available to the public. This could limit the choices to field data in the public domain.

3. The producing field has an EOR project. This is necessary for testing the model, once developed, with actual field data.

These factors must be weighed along with the EOR potential of the depositional environment in the final selection.

It should be emphasized, however, that since the overall objective here is to develop and test a methodology applicable to many reservoirs of diverse origins, it is not necessary to choose the depositional environment with the highest OOIP and the highest ROS after waterflooding. Rather, an environment should be selected that is relatively important as a reservoir and EOR target and that reasonably meets the other criteria, but it should also exhibit a degree of complexity appropriate for the initial development of a methodology.

Deltaic and turbidite environments, although prolific producers, were not considered for heterogeneity research because (1) they form extremely complex reservoirs, which is undesirable for the initial development of a methodology and (2) no field is known that satisfies the three criteria: (a) the productive formation is exposed nearby, (b) subsurface data are available to NIPER, and (c) the field has an EOR project.

RESERVES

Two depositional environments satisfy the above requirements: barrier island/strandplain deposits and shelf sand ridge deposits. More than one-half (51 percent) of North America's giant oilfields produce from clastic reservoirs interpreted by Moody, et al[1]. to be shallow marine and near-shore (littoral) deposits (figure 1). Results of a survey of 77 fields producing from barrier/strandplain deposits and 22 from shelf deposits indicate that both environments are economically important on this continent. (See appendix A.) Of these, six barrier fields and two shelf fields are U.S. giant oilfields (ultimate recovery > 100 million barrels). Thirteen fields producing from barrier deposits and three fields producing from shelf deposits

have ultimate recoveries estimated at more than 50 million barrels (tables 1 and 2).

Names of fields producing from a combination of barrier/strandplain and shelf sands are presented in table 3. Two of these fields have ultimate recoveries of >500 million barrels.

This survey of fields is a partial list (appendices A and B) and is intended only to illustrate examples of economically important fields producing from the depositional environments of interest. A complete list, useful for statistical comparisons, would be difficult and extremely time consuming to compile for the following reasons:

1. Depositional environments are often not well understood, have conflicting interpretations, or are not reported in the literature.

2. Many fields produce from multiple zones representing diverse depositional environments; production and reserve figures are not calculated for individual zones.

3. Reservoirs producing from shelf sand ridge deposits probably are not well represented in the literature because only recently have shelf sand ridge deposits been described and recognized as discrete deposystem types.

4. Areas where large amounts of data are available (e.g. Texas) tend to bias the data set.

EOR POTENTIAL (ROS AFTER WATERFLOOD)

Information and data resulting from 22 EOR projects conducted in barrier/strandplain deposits and four conducted in shelf deposits are presented in tables 4 and 5, respectively. The data illustrate that both types of deposits are EOR targets. ROS after primary and secondary recovery in the 15 barrier fields sampled ranges from 31.5 percent to 55 percent and

averages 38.7 percent. The difference between ROS after primary and secondary recovery and ROS after tertiary recovery ranges from 24 percent to 1 percent and averages 7.6 percent. This suggests that barrier/strandplain reservoirs are good candidates for EOR and also that improvements could be made in recovery efficiency. Insufficient data exist for shelf sand ridge fields to make comparisons.

OTHER CRITERIA

Reservoirs in both barrier/strandplain and shelf sand ridge deposystems satisfy the other criteria of (1) an existing outcrop-reservoir pair, (2) available subsurface data, and (3) existing reservoir with an EOR project. Bell Creek field produces from a barrier/strandplain deposit, the Muddy sandstone, which crops out nearby. Much of the published subsurface data are available in DOE reports. Verbal consent was given by Gary-Williams Oil, the operator, to supply additional data, if needed. Two micellar-polymer EOR projects have been implemented in Bell Creek field.

Teapot Dome field (NPR-3) produces from the Shannon sandstone which is extensively exposed within 5 miles of the reservoir. Most of the well logs and core analyses from the field are available at NIPER; additional data are available from the NPR office in Casper. Three pilot EOR projects (polymer, in situ combustion, and steam), have been implemented in the Shannon in Teapot Dome field. More information on these reservoirs as well as the final selection of a reservoir for heterogeneity research will be reported later.

SUMMARY

1. Criteria for selection of a depositional environment for study are as follows: (a) it must be of relatively important economic value, (b) it must be a good EOR candidate, (c) the productive formation must be exposed near a producing field, (d) subsurface data for the producing field are available to NIPER, and (e) the producing field must have an EOR project.

2. Barrier/strandplain deposits and shelf sand ridge deposits meet criteria a, b, c and e. Satisfaction of criterion d is being investigated for both candidate deposystems prior to selection of deposystem for further study.

RECOMMENDATION

It is recommended that either barrier/strandplain or shelf ridge deposits be selected for heterogeneity research, depending upon the availability of outcrop and reservoir data.

BIBLIOGRAPHY

1. Moody, J. A., J. W. Mooney, and J. Spivak. 1968, Giant Oil Fields of North America, in Halbouty, M. T., ed., Geology of Giant Petroleum Fields, AAPG Memoir 14, 1970.

2. Galloway, W. E., T. E. Ewing, C. M. Garrett, N. Tyler and D. G. Bebout. Atlas of Major Texas Oil Reservoirs, Bureau of Economic geology, Austin, TX., 1983.

3. Hearn, C. L., Eubanks, Jr., W. J., Tye, R. S., and Rangnathan, V. Geological Factors Influencing Reservoir Performance of the Hartzog Draw Field, WY. J. Pet. Tech., August 1984, pp. 1335-1344.

4. Nehring, Richard. The Discovery of Significant Oil and Gas Fields in the United States. Report R-2654/2-USGS/DOE, 1981.

5. American Petroleum Institute. Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada as of December 31, 1979. API Trans., 34, June 1980.

6. Crews, G. C., Barlow, Jr., J. A., and Haun, J. D. Upper Cretaceous Gammon, Shannon, and Sussex sandstones, Central Powder River Basin, Wyoming. Proc. Wyoming Geol. Assoc. 28th Annual Field Conference 1976, pp. 9-19.

7. Conybeare, C. E. B. Geomorphology of Oil and Gas Fields in Sandstone Bodies, Elsevier Publishing Co., New York, 1976.

8. Mallory, William W., Ed., Geologic Atlas of the Rocky Mountain Region, Rocky Mountain Association of Geologists, Denver, 1972.

9. McCubbin, D. G. Facies and Paleocurrents of Gallup Sandstone, Model for Alternating Deltaic and Strandplain Progradation (abs): AAPG Bull.56, 1972, p. 638.

10. Tillman, R. W. and Martinsen, R. S. The Shannon Shelf-Ridge Sandstone Complex, Salt Creek Anticline Area, Powder River Basin, Wyoming, in Tillman, R. W. and Siemers, C. T. (eds), Siliciclastic Shelf Sediments, Soc. Econ. Paleontologists and Mineralogists, Spec. Pub. No. 34, 1984.

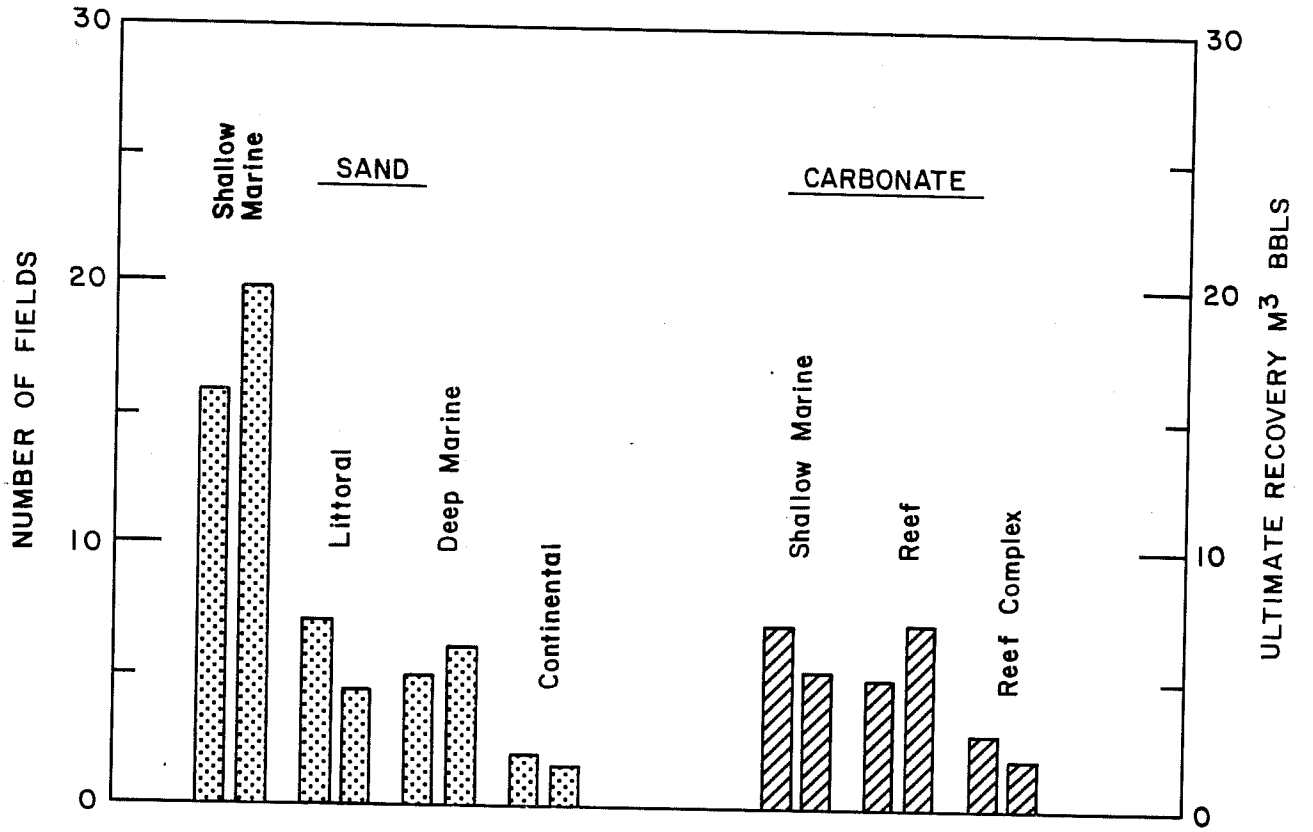

FIGURE 1. - Reservoir lithology by depositional environment of 45 North America giant oilfields.

Note: Bars are paired: left-hand bar of each pair gives number of fields, right-hand bar gives ultimate recovery. (After Moody, et al., 1968 (1)

Table 1. - Reservoirs producing oil from barrier/strandplain deposits
(Ultimate recovery >50 million barrels)

Field	State	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
			(millions of barrels)			
Tom O'Connor 5900	TX	Frio	549	246.3	337.0	2
Tom O'Connor 5800	TX	Frio	422	244.0	252.0	2
Greta 4400	TX	Frio	313	124.7	147.0	2
Tom O'Connor 5500	TX	Frio	261	77.7	140.0	2
West Ranch Greta	TX	Frio	223	73.9	111.0	2
West Ranch 41-A	TX	Frio	203	84.6	94.0	2
Magnet-Whithers	TX	Frio	163	78.6	91.3	2
Big Piney/ LaBarge	WY	Almy	--	65.	91	3
Govt Wells, North G W	TX	Jackson-Yegua	150	77.3	78.0	2
Lake Pasture H-440S	TX	Frio	132	37.7	74.0	2
Old Ocean Armstrong	TX	Frio	136	67.3	69.0	2
White Point E Brighton	TX	Frio	119	64.5	66.0	2
Seven Sisters	TX	Jackson-Yegua	142	35.0	56.0	2
Plymouth Heep Greta	TX	Frio	113	53.4	55.4	2
Withers North	TX	Frio	100	49.0	50.00	2

Table 2. - Reservoirs producing oil from shelf sand ridge deposits
(Ultimate recovery >50 million barrels)

Field	State	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
			(millions of barrels)			
Sussex	WY	Shannon/Sussex	--	59	66.3	2
Hartzog Draw	WY	Shannon	350 STB	32 STB	100	6
Meadow Creek	WY	Shannon/Sussex	--	92	108	2
Teapot East	WY	Shannon/Frontier Muddy	--	10.7	54	1

Table 3. - Reservoirs producing oil from combined barrier/strandplain and shelf sand ridge deposits

Field	State	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
			(millions of barrels)			
Pembina	Canada	Cardium	--	436	1773	1
Salt Creek	WY	Frontier FM (Second Wall Creek)	1518	576	789	5
Viking	Canada	Viking	320	--	110	7
Big Muddy	WY	Frontier	91.4	52	53	3
Garrington	Canada	Cardium	190	--	40	7
Bisti	NM	Gallup	200	33.4	34.6	3
Elk Basin	WY/MT	Frontier FM (Second Wall Creek)	998	467	--	5
Teapot Dome	WY	Muddy/Frontier/ Shannon	275	13.7	--	5
Crossfield	Canada	Cardium	160	--	16	7

Table 4. - EOR projects[1] in barrier island/strandplain reservoirs

Field	State/County	Payzone	EOR process	K md	Ø %	Depth, ft	Previous production	ROS % Start	ROS % End	Project evaluation	Profit	Reference for depositional environment
La Barge	WY/Sublette	Almy	Steam	100	25	850	WF	55	55	Disc(4/83)	No	7
Ruben	WY/Sublette	Almy	Polymer	1-56	14	330.0	Prim	42	45.4	Succ	Yes	7
McDonald Draw	WY/Sublette	Almy	Polymer	1-200	18	320.0	WF	43.8	29.1	Succ	Yes	7
McDonald Draw	WY/Sublette	Almy	Polymer	2-59	16.7	305.0	WF	40.3	36.7	Succ	Yes	8
Isenhour	WY/Sublette	Almy	Polymer	1-25	15-20	360.0	Prim	38.1	27.0	Succ	Yes	7
Long Island/ Star Corral	WY/Sublette	Almy	Polymer	1-50	15.5	355.0	Prim	43.6	23.9	Succ	Yes	7
Tip-Top Shallow Unit	WY/Sublette	Almy Mesaverde	Polymer	1-200	12-20	1150	Prim	41.3	36.9	Disc (1983)	No	7
Sage Spring Creek-Unit A	WY/Natrona	Dakota	Polymer	50	13	7400	WF	45	21	Succ	Yes	8
Big Muddy	WY/Converse	Wall Creek	Polymer	52	19.5	3180	Prim/WF	--	--	Disc (10/85)	No	
Clareton	WY/Weston	New Castle	Polymer	1-15	15-18	6000	Prim	--	--	Tett		8
Mush Creek	WY/Weston	New Castle	Polymer	1-15	15-18	4400	Prim	--	--	Succ	Yes	8
Bison Basin	WY/Fremont	Frontier	Alkaline	144	22	1300	Prim	--	--	Prom	--	8
Horseshoe Gallup	NM/San Juan	Gallup	Polymer	14	15	1200	WF	--	--	Disc	No	9
Bell Creek	MT/Powder	Muddy	Micellar Polymer	1218	24.9	4500	WF	33	21.5	Succ	Yes	
Bell Creek	MT/Powder	Muddy	Micellar Polymer	1050	27.0	4650	WF	35	25	Disc	No	
Bridger Lake	UT/Summit	Dakota	Hydrocarbon Miscible	70	12.8	15,600	WF	37	32	Disc	No	8
Withers, North	TX/Wharton	Frio (Withers N)	CO_2 Immiscible	1050	25	5,250	Prim	35	32	Prom	Yes	2
Withers, North	TX/Wharton	Frio (C-Sand)	CO_2 Immiscible	400	25	5,320	WF	32	30	Disc (Term. 1/85)	No	2
Plymouth	TX/San Patricro	Frio	CO_2 Immiscible	350	31	4,650	Prim	31.5	20	Disc (Term. 1/85)	No	2

Table 4. - EOR projects[1] in barrier island/strandplain reservoirs (cont.)

Field	State/County	Payzone	EOR process	K md	Ø %	Depth, ft	Previous production	ROS % Start	ROS % End	Project evaluation[2]	Profit	Reference for depositional environment
Pickett Ridge	TX/Wharton	Frio	CO_2 Immiscible	1200	30	4,600	Prim	29	28	--	No	2
Magnet Whithers	TX/Wharton	Frio	CO_2 Immiscible	1700	23	5,500	Gas Injection	35	31	Succ	Yes	2
Magnet Whithers Pierce Estates B&C	TX/Wharton	Frio	CO_2 Immiscible	1700	23	550	Gas Injection	35	34	Succ	Yes	2

[1]Oil and Gas Journal, April 14, 1986.
[2]Project evaluation:
Prom. = Promising
Succ. = Successful
Disc. = Discouraging

Table 5. - EOR projects[1] in shelf sand ridge deposits

Field	State/County	Payzone	K EOR Process	Ø md	Depth, %	ft	Previous production	ROS (%) Start	ROS (%) End	Project evaluation[2]	Profit	Reference for depositional environment
NPR-3 Teapot Dome	WY/Natrona	Shannon	Polymer	63	18	550	Prim	40	29	Disc	No	10
NPR-3 Teapot Dome	WY/Natrona	Shannon	Combustion	135	18	270-425	Prim	40	12-15	--	--	10
West Sussex Unit	WY/Johnson	Shannon	CO_2 Miscible	121	19.5	3040	--	--	--	(Term)	--	10
Dugot Creek	WY/Johnson	Shannon	CO_2 Miscible	120	22	2000	WF	--	--	Prom	--	10

[1] Oil and Gas Journal, April 14, 1986.

[2] Project evaluation:
Prom. = Promising
Succ. = Successful
Disc. = Discouraging

Appendix A. - Reservoirs producing oil from barrier/strandplain deposits

Field	State/County	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
			(millions of barrels)			
Elk Basin	WY/MT	Frontier FM (Second Wall Creek)	998	467	--	1
Big Piney/ LaBarge	WY/Sublette	Almy	--	65	91	2
Bell Creek	MT/	Muddy SS	244	77.5	150	2,5
Patrick Draw	WY	Almond	200-250	--	--	5
Amelia Frio 6	TX		47	27.5	34.2	9
Lovell's Lake Frio	TX	Frio (Buna)	20	10.3	10.6	9
Lovell's Lake Frio	TX	Frio (Buna)	42	30.2	30.2	9
Aransas Pass	TX	Frio	44	20.1	20.5	9
Arnold David Chapman	TX	Frio	21	10.3	10.7	9
Bloomington 4600	TX	Frio	69	30.5	31.4	9
Bonnie View	TX	Frio	50	19.1	19.5	9
Flour Bluff Phillips	TX	Frio	37	18.7	18.8	9
Francitas North	TX	Frio	25	13.1	13.2	9
Ganado West 4700	TX	Frio	44	13.5	23.4	9
Greta 4400	TX	Frio	313	124.7	147.0	9
Heyser 5400	TX	Frio	90	10.4	48.7	9
Lake Pasture H-440S	TX	Frio	132	37.7	74.0	9
La Rosa 5400	TX	Frio	20	10.0	10.0	9
La Rosa 5900	TX	Frio	23	12.0	14.2	9
La Ward North	TX	Frio	68	18.7	20.0	9
Lolita Marginulia	TX	Frio	32	16.2	17.2	9
Lolita Ward Zone	TX	Frio	29	17.4	18.0	9
London Gin Doughty	TX	Frio	24	14.2	15.0	9
Magnet-Whithers	TX	Frio	163	78.6	91.3	9
Markham N-BCN Carlson	TX	Frio	20	10.7	11.5	9
Markham N-BCN Cornelius	TX	Frio	36	9.7	22.0	9

Appendix A. - Reservoirs producing oil from barrier/strandplain deposits (Continued)

Field	Stat/County	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
			(millions of barrels)			
Maurbro Marginulina	TX	Frio	51	24.7	26.0	9
McFaddin 4400	TX	Frio	51	22.4	24.3	9
Midway Main Midway	TX	Frio	60	16.6	17.0	9
M.E. O'Connor FQ-40	TX	Frio	45	17.3	18.0	9
Old Ocean Armstrong	TX	Frio	136	67.3	69.0	9
Old Ocean Chenault	TX	Frio	27	10.2	10.3	9
Pickett Ridge	TX	Frio	27	15.8	16.2	9
Placedo 4700 Sand	TX	Frio	77	41.4	45.0	9
Plymouth Heep	TX	Frio	113	53.4	55.4	9
Portilla 7300	TX	Frio	25	11.7	12.6	9
Portilla 7400	TX	Frio	75	42.3	46.7	9
Sugar Valley N	TX	Frio	21	6.3	6.5	9
Laurence Taft 4000	TX	Frio				
Tom O'Connor	TX	Frio	45	24.8	26.0	9
4400	TX	Frio	30	11.0	16.0	9
Tom O'Connor 4500 Greta	TX	Frio	59	15.9	33.0	9
Tom O'Connor 5500	TX	Frio	261	77.7	140.0	9
Tom O'Connor 5800	TX	Frio	422	244.	252.0	9
Tom O'Connor 5900	TX	Frio	549	246.3	337.0	9
West Ranch Glasscock	TX	Frio	127	50.3	53.0	9
West Ranch Greta	TX	Frio	223	73.9	111.0	9
West Ranch Ward	TX	Frio	69	36.2	37.0	9
West Ranch 41-A	TX	Frio	203	84.6	94.0	9
West Ranch 98-A	TX	Frio	82	45.3	47.0	9
White Point E Brighton	TX	Frio	119	64.5	66.0	9
Withers North	TX	Frio	100	49.0	50.0	9
Aviators Mirando	TX	Jackson-Yegua	37	10.1	10.3	9

Appendix A. - Reservoirs producing oil from barrier/strandplain deposits (Continued)

Field	State/County	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
			(millions of barrels)			
Colorado Cockfield	TX	Jackson-Yegua	52	21.7	21.8	9
Conoco Driscoll U 1G W	TX	Jackson-Yegua	69	20.0	23.7	9
Escobas Mirando	TX	Jackson-Yegua	28	12.8	12.9	9
Govt Wells, North G W	TX	Jackson-Yegua	150	77.3	78.0	9
Govt Wells, South G W	TX	Jackson-Yegua	40	16.6	18.0	9
Hoffman Dougherty	TX	Jackson-Yegua	55	20.5	21.0	9
Loma Novia Loma Novia	TX	Jackson-Yegua	176	47.7	48.0	
Lopez First Mirando	TX	Jackson-Yegua	75	30.4	33.0	9
Mirando City Mirando	TX	Jackson-Yegua	46	12.1	12.1	9
O'Hern Pettus	TX	Jackson-Yegua	83	22.2	30.0	9
Pettus Pettus	TX	Jackson-Yegua	46	16.2	17.0	9
Piedre Lumbre G W	TX	Jackson-Yegua	95	20.7	22.0	9
Prado Middle Loma Novia	TX	Jackson-Yegua	38	10.4	23.7	9
Seven Sisters G W	TX	Jackson-Yegua	142	35.0	56.0	9

Appendix B. - Reservoirs producing oil from shelf sand ridge deposits
(Ultimate recovery >50 million barrels)

Field	State	Payzone	OOIP	Cumulative production	Ultimate recovery	Ref. No.
				(millions of barrels)		
House Creek	WY	Suxxex	--	8.7	20	2,4
Heldt Draw	WY	Shannon	--		--	4
Holler Draw	WY	Shannon	--		--	4
Triangle U	WY	Shannon	--	10	--	4
Jepson Draw	WY	Shannon	--	--	--	4
Flying E	WY	Shannon	--	--	--	4
West House Creek	WY	Suxxex	--	--	--	4
East Heldt Draw	WY	Shannon	--	--	--	4
Teapot Dome NPR-3	WY	Shannon	181	--	--	
Sussex	WY	Shannon/Sussex	--	59	66.	2
Sussex W	WY		--	14.9	20.5	2
Hartzog Draw	WY	Shannon	350 STB	32 STB	100	6
Meadow Creek	WY	Shannon/Sussex	--	96	108	2
Meadow Creek	WY	Shannon/Sussex	--	10	10.1	2
Culp Draw	WY	Shannon	--	--	--	
Pine Tree	WY	Shannon	--	--	--	
Pumpkin	WY	Shannon	--	--	--	
Butte	WY		--	--	--	
Meadow Creek East	WY	Shannon/Sussex	--	--	--	
Gas Draw	WY	Mudd FM (Gas Draw SS)	--	22	27	2
Teapot East	WY	Shannon/Frontier	--	10.7	55	1
	WY	Muddy				
Olympic	OK	Olympic SS	--	12	--	7